PHOTOGRAMMETRIC SURVEYS FOR NAUTICAL CHARTING USE OF COLOR AND INFRARED PHOTOGRAPHY

CAPTAIN, LAWRENCE W. SWANSON

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USE OF COLOR AND INFRARED PHOTOGRAPHY

by

Captain L. W. Swanson
Chief, Photogrammetry Division
United States Coast and Geodetic Survey

ABSTRACT: One of the principal functions of the Coast and Geodetic Survey is to provide nautical charts of the $2\frac{1}{2}$ million square miles of coastal waters of the United States and its possessions, and the Commonwealth of Puerto Rico. Photogrammetry has become a recognized method of production, maintenance, and revision for these charts. Our photogrammetric procedures have been developed over the last 30-odd years using nine-lens and single-lens photography to perform aerotriangulation, to prepare detailed large scale maps, and to correct the aids, landmarks, and land features. Our first color photography was taken two years ago and exceeded our expectations in the amount of detail available which could not be seen on panchromatic photography. The color photography is now used to locate aids to navigation, to position channels and shoals, rocks awash and slightly submerged rocks, and small inlets that shift and change with storms. We are looking forward to the time when color emulsions on low shrink film base and a means of making color diapositives will be available. The present plotting equipment is not satisfactory for use with the existing color transparencies. We are experimenting with improvements for our instruments to enable us to use the color transparencies and we have prepared black and white diapositives directly from the color transparencies for use on the Kelsh Plotter. Infrared photography is also in use to give us the strong contrast between water and land areas for more exact determination of shorelines.

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Using color aerial photography for chart making will probably seem a bit strange to the surveyor and downright queer to the mariner--but we are finding that it provides an "all-seeing" eye for the detection of detail and an extremely valuable accessory for the maintenance of up-to-date nautical charts.

The purpose of this paper is to briefly tell about the advantages of color for certain phases of chart making. However, in order to provide a background for my subject, I must digress a bit to tell you about one of our particular, and perhaps rather unique, charting problems.

One of the principal functions of the Coast and Geodetic Survey is to provide nautical charts of the $2\frac{1}{2}$ million square miles of coastal waters of the United States and its possessions, and the Commonwealth of Puerto Rico. This requires the publication and maintenance of about 820 individual charts. This is quite a sizable area but size alone is not the principal feature.

We are favored with many bays and harbors and extensive intracoastal waterways--particularly along the Atlantic Coast, the Gulf of Mexico, and in Alaska. All in all, a shoreline totaling over 100,000 miles and thousands of miles of protected or intracoastal waterways that require the greater portion of the 16,000 fixed aids (lights and day beacons) and 24,000 buoys that are maintained for the mariner. As a consequence, over 80%, or about 670 of the 820 charts are published at scales of 1:40,000 or larger for navigation in these more or less restricted intracoastal waters:

WHERE THE NAVIGATOR IS RELATIVELY CLOSE TO LAND.

WHERE SHOALS ARE OFTEN EXTENSIVE AND THE CHANNELS INTRICATE.

WHERE FREQUENT REFERENCE MUST BE MADE TO LANDMARKS, TO LIGHTS AND BUOYS, AND TO FEATURES OF THE NEARBY LAND.

We hold that a nautical chart is an instrument of navigation that must be kept up to date to serve its intended purpose, i.e., to insure the safety of navigation. The larger part of our charting effort is devoted to maintenance, particularly the maintenance of the considerable number of large scale charts. For example, in 1960 we published only 13 new and reconstructed charts but we revised and reprinted 440 charts, or over 50% of the total number of charts on issue.

It is against this background of large scale charts with their requirement for frequent revision that our photogrammetric procedures have been developed over the last 30-odd years. We use nine-lens and single-lens photography together with limited ground surveys and stereoscopic plotting instruments:

1. TO PERFORM AEROTRIANGULATION, to position landmarks and aids to navigation, to provide alongshore control points for inshore hydrography, and to position individual models for map compilation.

2. TO PREPARE DETAILED LARGE SCALE MAPS showing the shoreline, alongshore rocks and structures, indications of shoals and channels visible in the photographs, and the land features adjacent to the shore. These are prepared ahead of hydrography for the guidance of the hydrographer and are used together with the hydrographic survey for the construction or revision of the chart.

3. TO CORRECT THE AIDS, LANDMARKS AND LAND FEATURES ON CHART DRAWINGS directly from new aerial photography to bring this information up to date just prior to reprinting and reissue of the chart.

We took our first experimental color photography just three years ago in reference to an unusual shoreline mapping problem--we were amazed and delighted with its ability to RECORD, AND TO SEPARATE DETAILS NOT SEEN ON PANCHROMATIC FILM. The amount of field work required in our photogrammetric mapping is generally in inverse ratio to the clarity with which certain features such as landmarks, lights and beacons, rocks awash, and inlying shoals and channels can be seen and identified with certainty on aerial photographs.

In this respect color photography is saving us time and money and giving us more up-to-date charts--it is already in general use in the Coast Survey as a supplement to our usual panchromatic mapping photography.

We are using and beginning to use color photography:

1. TO IDENTIFY AND TO LOCATE AIDS TO NAVIGATION.

2. TO MAP THE TOPOGRAPHY OF UNEVEN BOTTOM IN SHOAL WATERS TO ASSIST THE HYDROGRAPHER IN DEVELOPING AND SWEEPING THESE AREAS.

3. TO MAP ALONGSHORE ROCKS AWASH AND SLIGHT SUBMERGED ROCKS IN PLACES WHERE THESE ARE CLOSE TO TRAFFIC LANES AND FOR ANY REASON DIFFICULT TO DEVELOP IN DETAIL BY SOUNDING.

4. TO INVESTIGATE CHANGES IN SHORELINE AND ENTRANCE CHANNELS AT INLETS AND FREQUENTLY TO REVISE THESE FEATURES.

5. TO ASSIST THE COAST GUARD IN THE INVESTIGATION OF ACCIDENTS INVOLVING AIDS TO NAVIGATION REPORTED MISSING OR OUT OF POSITION.

One of the principal uses of color aerial photography is to locate lights, day beacons and buoys moved by storms or collisions so that the charted positions can be corrected. The charts can also be kept up to date by showing cultural changes from the color photographs without the necessity of a field examination.

The virtue of color photography is in the fact that it is usually possible to identify and locate the aid by office examination of the photographs and office plotting without a trip to the field. Formerly, we had to locate these by ground survey, or visit the area to identify them on panchromatic photography, or target the aids prior to panchromatic photography, each a costly and time consuming task.

As I mentioned before, there are some 40,000 aids--most of them in the bays, harbors, and intracoastal waters--and a large proportion of them subject to change: BUOYS AND SINGLE PILE STRUCTURES ARE MOVED BY ICE, OR NOT TOO INFREQUENTLY, KNOCKED OUT BY PASSING VESSELS: AND CHANNELS AND SHOALS ARE CHANGED BY BOTH THE WORK OF MAN AND WEATHER.

We have been able to see the bottom, that is, to penetrate the water, with color photography to depths ranging from 8 or 10 feet in Alaska to 60 and even 70 feet over the coral bottom in certain parts of the Caribbean. At this time we are compiling bottom topography of an area off the coast of Puerto Rico and the Virgin Islands preparatory to hydrography. Bottom features are clearly visible on the color photography of this area. Depths measured on the Kelsh Plotter and corrected for refraction, when compared to prior hydrography, appear to be correct to plus or minus 5% to maximum depths of 70 feet.

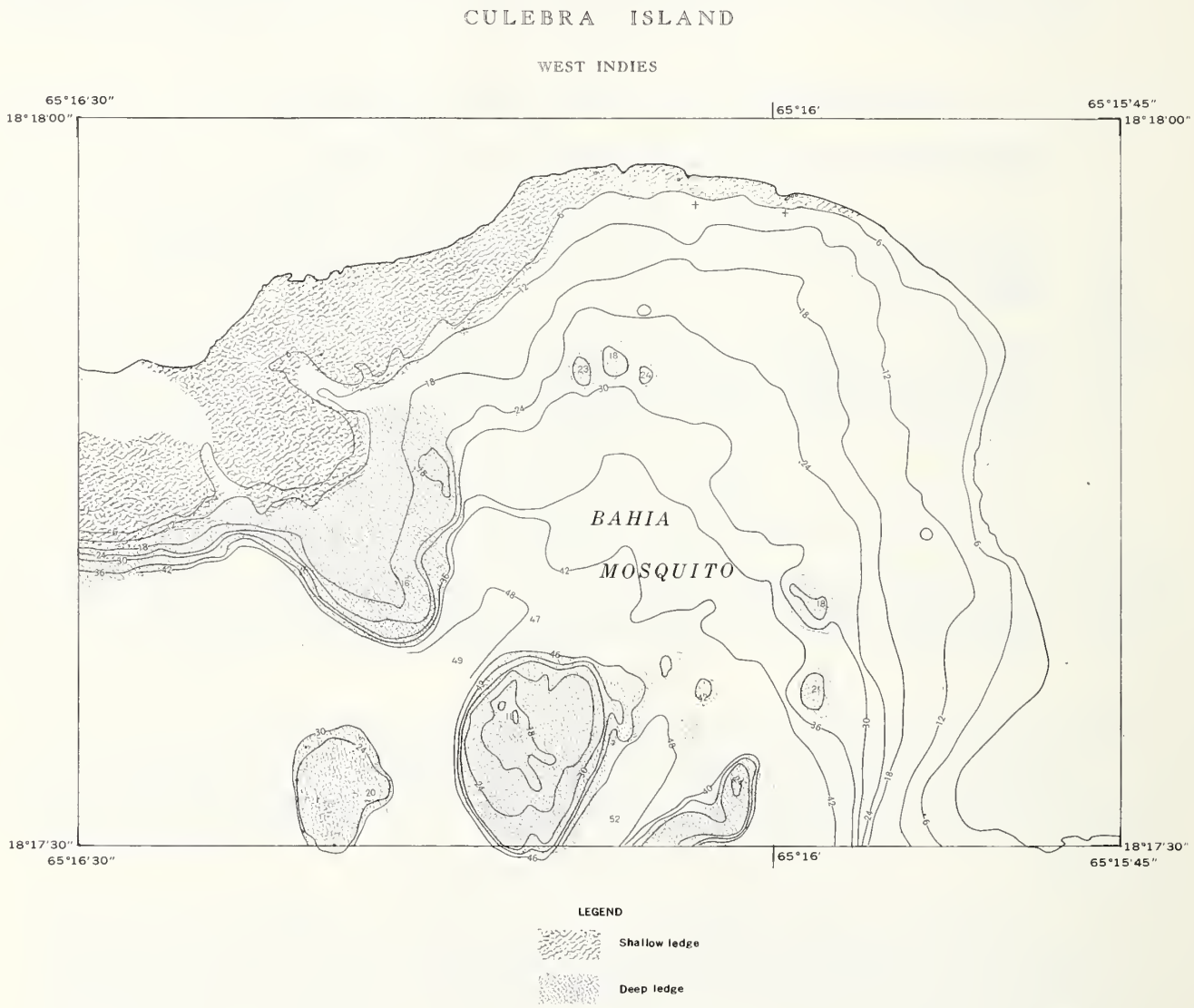

FIGURE 1

Figure 1 shows the bottom topography drawn from the color photographs by Kelsh Plotter. This is a section of a preliminary or reconnaissance map prepared as a guide for the hydrographer. Depths are approximate but the relative positioning of shoals, channels, and other submarine features is quite good. This information will be transferred to the boat sheet, or hydrographic work sheet, prior to hydrography and will indicate to the hydrographer the bottom features that require special development and also the maximum settings of the wire drag or sweep, in any given area.

This same information and the color photographs will also assist in the shaping of depth curves during the smooth plotting of the hydrography. In fact, the color photography will sometimes permit us to complete depth curves in shoal waters that were not completed by the hydrography. As an example, Figure 2 shows an area between Great St. James Island and Little St. James Island where during prior surveys no hydrography was done because of the difficulty of entry. The depth curves shown on Figure 3 in this passage were completed solely from color photography.

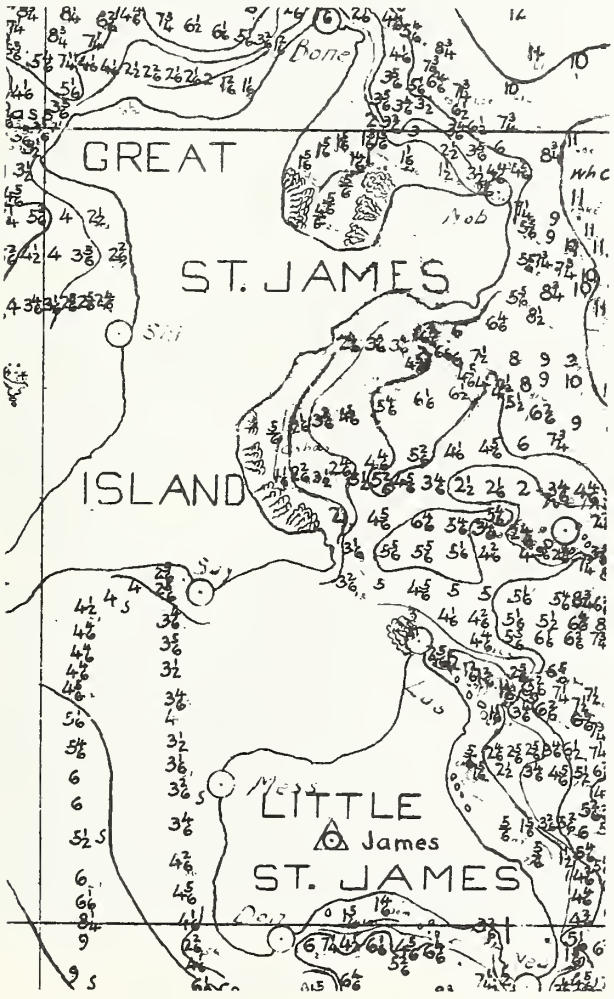

FIGURE 2

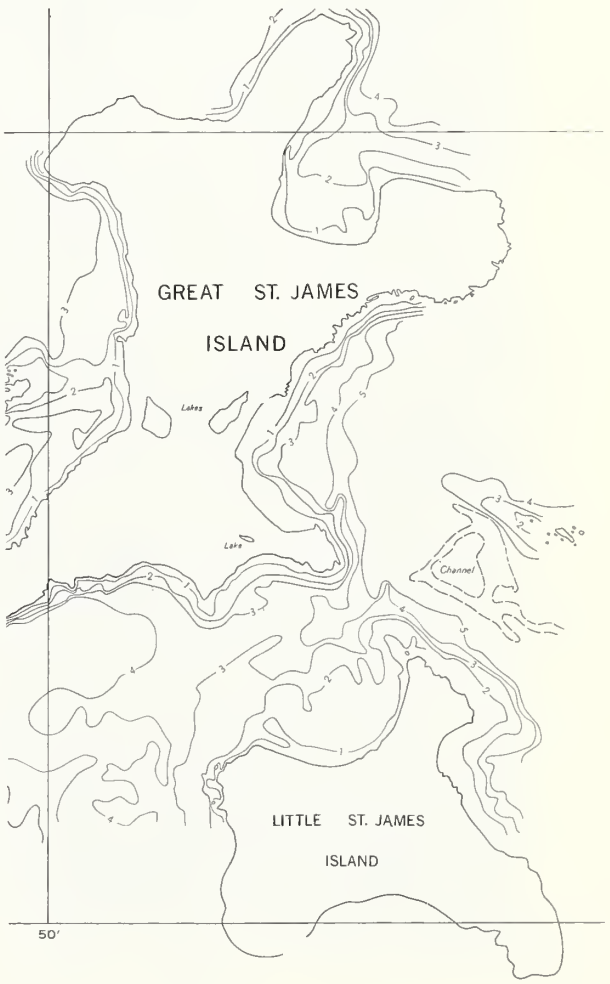

FIGURE 3

Along much of our coastline the depth of penetration by color photography will not be so great as in the area just illustrated. However, there will be many instances where color photography of bottom features to depths of but a few feet will be extremely helpful.

It is always helpful to position channels and shoals on the boat sheet prior to hydrography. We have always done this insofar as practicable on the maps that we prepare for the hydrography, but our panchromatic photography left much to be desired. Color photography clearly shows the limits of channels and the extent of shoals.

Rocks awash and those slightly submerged at low waters are particularly important when close to traffic lanes and it is not always easy to locate these features either by photogrammetry with panchromatic photography or by sounding. Color photography providing some penetration of the water is extremely helpful for this purpose.

We have many small inlets that shift and change with storms. We customarily revise the shoreline after such changes from panchromatic photography, and this is done quickly and readily. However, hydrography to detect changes in the channels at such inlets is a slower more tedious job. Color photography will often detect the fact that a channel has changed position and show the new position even though it can give us, thus far, only approximate information about the depth.

Our methods of plotting with color photography are thus far quite crude. We are using color transparencies. These are cut to individual photographs for stereoscopic viewing on a light table. When locating aids to navigation, radial templets are made on a light table and plotted to passpoints located by photogrammetric bridging with higher altitude panchromatic photography.

Color emulsions are not yet available on glass plates for plotting instruments. Consequently, we had to adopt an expedient that works quite well. We make contact prints from the color transparencies on to glass plates using the same emulsions ordinarily used for black and white diapositives. The result is a black and white diapositive with reversed tone. These emulsions happen to be blue sensitive and since the water areas are predominantly blue in tone they retain the depth penetration quality of the original color transparencies and are quite satisfactory for compilation of bottom topography on the Kelsh Plotter.

We look forward to the time when we will have color emulsions on a low shrink aerial film base and means of making color diapositives for use in stereoscopic plotting instruments, but we have not yet received much encouragement from industry and this seems to be well into the future.

In closing, I want to mention our use of infrared photography. For some years now we have found it to be an extremely helpful adjunct for mapping the shoreline. This is particularly true when we want an exact mean low-water, or mean high-water line or for that matter any shoreline contour. For charting purposes, the shoreline is the approximate mean high-water line which we customarily map using panchromatic photography which has been taken in the field to identify the shoreline by examination on the ground. However, a more exact delineationof the shoreline contour is occasionally necessary, and in such cases, we coordinate the photography with tide staffs and take infrared photographs at, or very nearly at, the exact stage of the tide. The contrast between land and water is strong so that the shoreline (high-water line, low-water line or any shoreline contour) can be accurately mapped with little or no field examination. Figures 4 and 5 illustrate the facility of infrared for this purpose. Figure 4 is a panchromatic photograph. Figure 5 is an infrared of the same area.

FIGURE 4 FIGURE 5

Cobscook Bay, Maine
October 1956